

BOTANY.—*Naming the cultivated rubber tree* *Siphonia ridleyana*.¹
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As indicated in Science,² historians of the rubber industry are seriously misled by confusion among the names of different trees in South America. The usual designation of the cultivated rubber tree is *Hevea brasiliensis*, but this is ambiguous on account of being borrowed from two other rubber trees. The generic name *Hevea* was transferred from a tree found by La Condamine in 1736 on the Pacific coast of Ecuador, and the specific name *brasiliensis* from a tree that Humboldt and Bonpland collected on the upper Orinoco in 1800. The generic name *Siphonia* has historic warrant for replacing *Hevea*, as will be explained. The specific name *Siphonia ridleyana* is suggested to commemorate the discovery by Henry N. Ridley of the method of extracting the rubber-bearing latex of this tree, which may be reckoned among the major events of history. No other domestication or introduction of a plant has such marked reactions on human affairs. The rubber discovery was made at the Singapore Botanic Gardens in 1889, as recounted by David Fairchild in the Journal of Heredity for May, 1928, from notes of a visit to Ridley in 1896.

Giving the cultivated rubber tree a name of its own may assist in clarifying some of the problems of production. This tree has been the subject of intensive investigation in the East Indies, but has had relatively little study in tropical America. The cultural problems are not the same in America, and a different approach is necessary on account of the *Castilla* or Central American rubber tree being much better known in most of the American countries. The original habitat of the cultivated rubber tree was in the lower Amazon Valley, while *Castilla* extended through tropical America from Mexico to Peru, Bolivia, and Brazil, several species being recognized.

Without Ridley's discovery there would have been no commercial planting of *Siphonia* in the East Indies, higher prices would have ruled, and some of the *Castilla* plantations in Mexico and Central America would have been profitable. In that event the planting of *Castilla* might have extended through tropical America and our present dangerous dependence on the East Indies would not have occurred. Markham's project of cultivating rubber in the East Indies would have miscarried, and Wickham's rape of the Brazilian rubber tree, dramatized by so many historical writers, could have had little significance. The industrial utilization of rubber doubtless would have

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² Science 85: 406-407. 1937.

gone forward but in different courses and much more slowly. The exploitation of wild rubber in Brazil would have been carried into more remote forests, with increasing difficulty and hardship among the laboring people, till cost limits were reached, or demands could be met from planted *Castilla* rubber. Planting *Siphonia* in Brazil was not feasible under the native method of tapping, and the native leaf disease is another obstacle not yet surmounted.

CASTILLA THE ORIGINAL RUBBER TREE

A general priority may be claimed for *Castilla* as a source of rubber, not only in Mexico and Central America, but also in South America. The labor required for gathering *Castilla* rubber is much less than with *Siphonia*, on account of the latex being more abundant and flowing more freely, but the trees are destroyed. It was not till the middle of the nineteenth century, after *Castilla* had been exhausted along the Amazon, that the Para rubber tree began to be exploited on a large scale. The extinction of *Castilla* is explained by the method of tapping, the trees being felled and ringed with tapping cuts at frequent intervals along the whole length of the trunk and the larger branches. Fifty pounds of rubber may be obtained from a large *Castilla* tree, though most of the latex remains in the bark. *Castilla* rubber is essentially the same as *Siphonia* rubber, but requiring different treatment, like cane sugar and beet sugar.

The idea of replacing the natural resources of wild rubber with cultivated trees was entertained much earlier in Mexico, some of the planted *Castilla* trees dating back to 1867, nearly 30 years in advance of the commercial planting of *Siphonia* in the Malay Peninsula. Thousands of acres were set with *Castilla* trees in southern Mexico near the end of the last century, before the East Indian rubber industry was developed. But Ridley's method of tapping could not be applied to *Castilla*, and the Mexican rubber plantations became a complete failure.

The differences between the two principal types of rubber trees need to be clearly understood, and also the nature of Ridley's discovery, before the problems of utilization can be approached to full advantage in tropical America. The *Siphonia* tree, because it was limited in nature to Brazil and as yet has been cultivated chiefly in the East Indies, comes to most of the American countries as a new introduction, and inevitably is viewed from the standpoint of experience with the local *Castilla* tree, which proved disappointing. *Siphonia* often appears less promising than *Castilla*, until the differences are

appreciated. In early plantings of the two trees, in Haiti and in Panama, *Siphonia* was reckoned as a complete failure, and the trees cut down, on account of the smaller flow of latex, before Ridley's method of repeated tapping of *Siphonia* became known. The secret lies in the latex tubes of *Siphonia* uniting into a network. The latex tubes of *Castilla* do not form a connected system, the flow of latex does not continue, and the *Castilla* trees are soon killed by severe tapping. Mechanical extraction is possible by harvesting the entire *Castilla* tree as a forest product, as explained in Science, April 23, 1937, but *Siphonia* is superior as a plantation tree, producing rubber in a few years and yielding regularly.

CONFUSION OF THE NAMES

The cultivated rubber tree is known to have been carried to the East Indies from the lower Amazon Valley, and often is called "the Para rubber tree," but is stated in many reference works to have been discovered in the forest of Esmeraldas on the Pacific coast of Ecuador by the French engineer-astronomer La Condamine in 1736. In reality, neither this tree nor any related species has been found in any locality west of the Andes, all the species of *Siphonia* being confined to the Amazon Valley or to the Atlantic watershed in Guiana and Venezuela.

The rubber tree of the Pacific coast district of Esmeraldas is a species of *Castilla*, like the Mexican and Central American rubber trees. The genus *Castilla* belongs to the breadfruit family, related to the fig and the Osage orange, while the Para rubber tree belongs to the spurge or euphorbia family, with the castor bean and cassava. *Castilla* is very widely distributed in tropical America, from Mexico to Brazil, had numerous uses among the natives, and furnished the early exports of rubber to Europe, not only from Mexico and Central America, but also from South America, including the Amazon Valley. The error of supposing that the Para rubber tree was discovered in Ecuador arises from the fact that the native name *heve*, relating in Ecuador to the *Castilla* tree, was carried to Guiana and erroneously used as the name of a genus, to which the Para rubber tree later was referred. The modern preponderance of the Brazilian rubber tree has left the error unrecognized.

La Condamine was the first European to foresee a commercial future for the strange elastic substance that others had passed as a curiosity. Two centuries earlier Sahagun had described the Mexican *ulli* as a very pliable resin (*resina muy correosa*) made into bouncing balls, and another century was to pass before Hancock and Goodyear

undertook its industrial development. La Condamine's interest in rubber was expressed in a report to the Royal Academy of Sciences at Paris in 1736, and led at Esmeraldas to a personal friendship with a capable young Spaniard named Maldonado, familiar with the native uses of rubber. Maldonado accompanied La Condamine on the return journey but died soon after reaching France, so that the rubber in Ecuador received no further attention.

Rubber was in demand, chiefly for candles and torches, and was being gathered in the upper Amazon Valley when La Condamine descended the river in 1743. Small objects modeled of rubber were seen at Para, and some of these were carried to French Guiana, where a search for rubber trees was started. Fresneau, an engineer who spent 14 years in this colony, found several latex-bearing trees, as reported through La Condamine to the Paris Academy in 1751. One of the Guiana trees was supposed from native information to be the kind that furnished rubber in Brazil, and this was described by Aublet in 1775 as *Hevea guianensis*. Several localities were noted, and the nuts were said to be gathered and eaten by the natives, the "almond" having a pleasant taste. La Condamine and Fresneau are not mentioned, but a reference is given to the "poor figure" of the Guiana tree in the memoir of 1751. The name "*Hevea peruviana*" engraved on Aublet's plate 335 leaves no doubt that the Guiana tree was supposed to be the same that La Condamine had found on the coast of Esmeraldas, "northwest of Quito," where *Castilla* grows, and the name *heve* was recorded.

Thus it came about that the name *heve*, used by the natives of Esmeraldas for the *Castilla* tree, was employed by Aublet as a generic designation for the Guiana rubber tree, and by later botanists it was extended to the Para rubber tree. Some writers have compromised by placing Esmeraldas in Brazil or in Venezuela, instead of in Ecuador, showing another kind of confusion that a misleading name may generate. Ducke says in a footnote of his *Revision of the Genus Hevea*, in 1935: "I do not know why Aublet attributed the origin of the name *heve* to Esmeraldas on the Pacific coast of Ecuador, where the genus *Hevea* is unknown." The reason is that the trees were assumed to be the same, since both produced rubber.

Aublet followed Plumier in using many native vernacular names as generic designations. Dozens of such names were adopted, some of them much alike and easily confused, as *Couepia*, *Coupoui*, *Couratari*, *Courbari*, *Couroupita*, *Coumarouna*, and *Coutoubea*. Linnaeus and his followers often rejected such vernacular names as "barbarous," but a

more serious objection may be seen in the lack of distinctive meaning, and the difficulty of remembering them as merely arbitrary collocations of letters or sounds. An authentic aboriginal name for an outstanding type, like *Mammea* for the mamey or marmee-apple of the West Indies, has meaning and historic interest, at least in its native country, but a misplaced aboriginal name, carried to a distant region and applied to a different plant, inevitably generates confusion.

SIPHONIA AN ALTERNATIVE NAME

To avoid the confusion thus inherent in the use of *Hevea* as a generic name for the cultivated rubber tree, the name *Siphonia* may be resumed, which had been the accepted name of the genus during three-quarters of a century and should have been retained. The return to *Hevea* by Mueller von Aargau in 1865 apparently was taken on grounds of priority alone, without considering that *Hevea* had been discarded as a homonym. The principle of priority, with its promise of greater stability in nomenclature, was coming into prominence in the time of Mueller, but priority alone is not a solution. It is only one of the principles that affect the utility of names. Under guise of priority many obscure names were taken up, which more careful study would have left in oblivion. The method of types, for fixing the original applications of generic names, received little attention from botanists until the last decade of the nineteenth century.

Specious arguments are made that rules of nomenclature should be set aside in dealing with names of important plants, to avoid troublesome changes. There is equal need to reflect that plants of special utility are more likely to receive historical study, and there is no assurance that "technical botany" will be appreciated for any special dispensations that would tend to confuse and obscure the early records. With the economic plants there is greater need of unequivocal names, not borrowed from other species. The taxonomic problems need to be studied with more care than has been customary, and with better appreciation of the various functions of botanical science in human welfare. Needless complications in codes of nomenclature are evidence of inadequate study. Our *International rules of botanical nomenclature* have a rather elaborate section on "Gender of Generic Names" but overlook an elementary rule of Latin grammar that has governed botanical usage, the rule that tree names and plant names take feminine adjectives, to agree with *arbor* or *herba* as an implied appositive.

The difficulties of changing names often are exaggerated, since

botanical workers are accustomed to the use of alternative names. The notion of new names being entered at once and old names summarily discarded, is found among indexers, cataloguers, or even herbarium assistants, rather than among experienced botanists, familiar with the use of names in the study of plants. The "old" names are not "wrong," unless they are given to the wrong plant. A familiar long-current name may continue for years to serve reference purposes, botanic, bibliographic, or commercial, better than a new name, unless both names can be given. The older names never are completely discarded, but remain in reference use among students of botany who have sufficient interest to follow the history of a plant to the original sources.

Changes of names necessarily are made gradually, since there is no escape under scientific methods from the fact that the acceptance of new names is determined eventually by knowledge of the plants. Like "patents applied for," new names obtain formal recognition when the descriptions are published, but general currency is not attained until other botanists have studied the plants and are convinced that the groups in reality are distinct from others previously known, or that the earlier names were not properly used. Practical tests of usage are not made unless suitable alternatives are available for names that are equivocal or confusing. A tree that has only an ambiguous, misleading name is less accessible to study.

Some of the changes of names result from new plants being discovered or mistakes corrected, while others arise from progress in classification through the discovery of new characters or relationships. It is a mistake to suppose that a completely uniform nomenclature is possible, or that a fixed system would be desirable in the present state of knowledge. All the names are provisional in the sense of requiring continued approval, and subject to change with increased knowledge. The notion of disregarding the names that were considered by their authors as provisional is one of the strange proposals in recent efforts to reform the system of nomenclature that would generate needless complications. In science as in other activities the tendency is for public interests to be treated casually, with the arguments often drifting away from the facts. The danger of science disintegrating into sterile specialties is not imaginary. Constructive reforms are needed to keep taxonomy as a part of the study of plants and to open this field of natural interest to a wider public. George Santayana's *Dia-logues in Limbo* satirize botany as a trivial, overtechnical science with a peevish insistence on "the right names for flowers."

RIDLEY'S FATEFUL DISCOVERY

A more fateful discovery than Ridley's method of harvesting the rubber of the *Siphonia* tree would be difficult to adduce from the pages of history. Many "epoch-making inventions" are recounted, but none that so promptly affected so many millions of people. In all civilized countries living conditions and social relations were profoundly changed in a few years. Even among primitive tribes in remote and backward regions of the Tropics, rubber cultivation had almost immediate effects. Thousand of Malays, Hindoos, and Chinese soon were engaged as contract laborers on the rubber plantations, while other thousands of even more primitive people were released from the gathering of wild rubber in forest regions of both hemispheres, and in effect were reprieved from extinction through Ridley's discovery.

A parallel may be seen in Eli Whitney's invention of the saw gin for short-staple cotton, which had social and political significance in the rapid expansion of Negro slavery in the Southern States, eventuating in the Civil War, but these effects were relatively local, while the rubber reactions are world-wide. The ascendancy of the northern nations of Europe may be ascribed to the introduction of the potato, but centuries were required for the potato sequence to work out, while less than half a century has elapsed since the first commercial planting of the *Siphonia* tree, in 1896.

To open new sources of rubber, the tropical world of both hemispheres was being ransacked before the first plantations began to produce. Hundreds of localized rubber-bearing plants had been found, trees, shrubs, and vines, and many of these were being intensively exploited, through natives enlisted as rubber-gatherers. Although commercial and industrial advantages are reckoned from such utilization of natural resources in primitive countries, the general effect is that the native populations are rapidly disorganized, depleted, and destroyed. The older rubber and chicle districts in southern Mexico and Central America were completely depopulated, and much of the rubber country in South America. Rubber-gatherers were recruited in the coast districts of Brazil and carried hundreds of miles to the rubber forests, where thousands perished. This period of frantic rubber-gathering reached an end when plantation rubber came into the market, and lower prices were in prospect. Gruesome chapters of exploitive savagery are outlined in the book entitled *Rubber, a story of glory and greed*, by Howard and Ralph Wolf, 1936.

Rubber production offered such immediate advantages that only a few years were required for a new agricultural industry to be created in the East Indies, and new manufacturing industries in Europe and America, providing new systems of communication and transportation in all civilized countries. Rubber and gutta-percha as insulating materials made it possible for electricity to be utilized. Our highly mechanized civilization often is symbolized as "the Rubber Age." Riding on rubber has become our "standard of living." A vast extension of the human environment has taken place.

Hundreds of chemical and physical discoveries have contributed to "modern scientific progress," but rubber in thousands of tons was necessary for the endless new applications to be developed. Ridley's biological observation was the critical point in quantity production, making it possible for our industrial and cultural transformations to go forward with such amazing speed. It might be said that Ridley turned on the rubber, and caused an industrial deluge. Even our "World Wars" and our "economic chaos" may be reckoned as consequences of Ridley's discovery, from facilities of transportation and communication being increased too rapidly for social adjustments to be made. Industrial populations "demand continuous prosperity" in order to furnish regular employment. Commercial rivalry is readily intensified to savage competition and national conflict.

RIDLEY A NATURALIST

It should not detract from our appreciation of Ridley's discovery that it was made under pioneer conditions and was not reported for several years, as Ridley explained in a letter to Fairchild, published in November, 1928, in the *Journal of Heredity*. Only a beginning was made, and scientific interest is not competitive. Ridley was not an inventor or an intensive specialist, but a naturalist, and the rubber tree with him was one of many concurrent interests. The tapping method was discovered casually, as a simple observation of latex flowing repeatedly from the same wound, and in larger quantity, after paring the cut.

It was known from Brazil that the first tapping drew little latex and was referred to as "calling the rubber." Hatchets were used for tapping in Brazil, gashing and scarring the trees, so that the surface in a few seasons became too rough for tapping to continue. The period of production would have been too short for plantations to have been practicable under the Brazilian method of tapping. Ridley's method replaced the many gashes with a single knife-cut, thus greatly reduc-

ing the labor of tapping, avoiding injury to the bark, and extending the period of production through many years.

Caring for the rubber trees at Singapore, as superintendent of the botanic gardens, did not make Ridley directly responsible for a study of methods of tapping. The extraction of rubber was viewed officially as a physiological problem and was being investigated at a laboratory in Ceylon. Notions of professional property might have kept Ridley's volunteer interest from being exercised. It was assumed in Ceylon that the Brazilian method of tapping with many small cuts would be followed, and on that basis there could be little outlook to commercial planting.

The theory of the wound response, as inducing a greater intensity of physiological action in the bark of the tree and thus increasing the flow of latex, has been reckoned as a scientific contribution from the work in Ceylon, but in reality it was erroneous and misleading. The underlying facts were determined by later investigators, that the latex system is continuous and that a more liquid latex, with a lower content of rubber, replenishes the tubes adjacent to the tapping cut, which explains the freer flow in the subsequent tappings. By virtue of the minute latex tubes uniting into a network, the entire system drains to a single outlet. The prompt replacement of the latex and renewal of the bark pressure may be viewed as a remarkable provision of the *Siphonia* tree against the wound reactions that otherwise might occur, if the tissues were depleted or were invaded by fungi or bacteria.

Novelty is not the naturalist's primary interest, nor is he intent upon the industrial or commercial utility of any fact that he may observe. The satisfactions of the naturalist are in seeing what nature affords. "I have never got over my astonishment at this world." Not only the lands and the landscapes, the towns and the belfries, call the naturalist, but all the forms of life, that he may "feast his heart." Bates, in *The naturalist on the Amazons*, recounts his years of unabated interest: "Although now a forest Rambler of ten years' experience, the beautiful forest which surrounds this settlement gave me as much enjoyment as if I had only just landed for the first time in a tropical country." "The saddest hours I ever recollect to have spent" were in leaving Brazil. "I felt that the last link which connected me with the land of so many pleasing recollections was broken."

Ridley was an explorer of the Malayan forests, but he also took account of the South American rubber trees in the Singapore Garden and became interested in the flow of latex, to the extent of making his

simple tests. He wanted to see how close the cuts could be made together and whether the flow would be affected. Different cuts were tried and gradually simplified to a sloping groove cut with a sharp gouge, with a thin layer removed every morning or at intervals of two or three days, thus obtaining a repeated flow of latex, through weeks, months, and years.

THE FIRST COMMERCIAL PLANTING

Ridley saw the bearing of his discovery, but its practical importance still had to be demonstrated by establishing rubber plantations. As Lamarek once reflected, making a fact known often is more difficult than discovering it. Although many planters were "strongly advised to turn their attention to this plant," several years passed before any individual was found with sufficient intelligence and courage to make such an experiment on a commercial scale. Fairchild says, in *The world was my garden*, that Ridley "complained of the lack of interest the British planters of the Malay States showed in this Brazilian rubber tree." How many British planters refused the distinction of pioneering the rubber industry is not stated, but in 1896, according to Ridley's report, "Mr. Tan Chay Yan was induced by the Director of the Botanic Gardens to plant rubber." The discovery might easily have miscarried and been forgotten. An accident to Ridley or to Yan might have turned the scale. There was only this "Chinaman's chance" of rubber being planted. To Ridley it seemed in order that the Gardens be used and appreciated, but not that he should turn aside from botany and make a million out of rubber. "Reward as such has nothing to do with the essential act of creating."

False impressions are conveyed by much that is written to advocate science. Special states of mind are supposed to be needed for making important discoveries. "Scientific discovery almost always depends upon a man's looking at something in the dry light of the intellect and isolating himself from the previous thoughts both of himself and other men about it." Forced abstraction, "supreme attention to one thing," may be a mental environment for logical analysis of formal problems but is no substitute for the naturalist's interest. "No remarkable discovery is in the power of anyone." Ridley's discovery was an accident, but one that could not occur without the trees at hand, and the attentive mind.

Nobody at that time had the idea of a rubber tree with a continuous latex system, that would provide a repeated flow of rubber milk by shaving the margin of the same wound every day or on alternate days.

Such a notion of rubber production would have seemed too fantastic to be credited, until it took body as a fact, after Ridley's discovery and demonstration. Goethe says that we see only what we know, but with each advance of knowledge somebody must see what has not been known, or even expected. This is the creative vision, to see things as they actually are, and to lay aside our former limitations. The expansion of the rubber industry, after the first plantation had succeeded, was so immediate and overwhelming that Ridley's discovery was generally overlooked and might have remained in oblivion if Fairchild's record had not been published.

The need for naturalists now seems greater than ever, on account of our present civilization being so badly overbalanced on the mechanical and industrial sides, even in the study of the biological sciences. Researches may be conducted in formal lines and elaborately recorded by men who are not naturalists, take little notice of outlying facts, and frame their structures of knowledge as closed systems. A misleading emphasis often is placed on logical or statistical analysis of facts that have been reduced to formal records, but without the naturalist's interest in the wider relations. The nature and extent of Ridley's interest may be followed in his many papers and books on the flora of the Malay region and in his massive work on *The dispersal of plants throughout the world*, published in 1930, a general treatise on the adaptive characters that determine the dissemination of plants. A review of his botanical work appeared in *Nature* for March 21, 1936, occasioned by his eightieth birthday, December 10, 1935.

Sending the tree abroad to let naturalists study it doubtless would have seemed a fantastic proposal. Progress is contingent on bringing the naturalists and the trees together. Brazil and other neighboring regions may be advantaged in the end from the knowledge obtained in foreign countries. Several eminent naturalists, as Martius, Wallace, Bates, and Spruce, spent many years in Brazil, but there the rubber trees are immersed with thousands of other species in the vast Amazonian forest, and detailed study is out of the question. Not until the trees are grown separately do their characters and habits become known. Even botanical specimens of the forest trees are seldom obtained, except as a good marksman may shoot down twigs or small branches with a rifle. The forest canopy of the tropical world is less explored than the polar ice-caps. Doubtless some botanical Byrd will rig a dirigible with a barge of canvas or wire netting that will rest on the roof of the forest and allow the treetops to be visited.

The chief discovery in South America regarding *Siphonia* is the

leaf disease caused by the fungus *Dothidella ulei*, or *Melanopsammopsis ulei*. This disease is a serious obstacle to open planting of *Siphonia* in Brazil, on account of many fatalities in the seedlings and juvenile stages, but Ridley's method of tapping is being applied to trees of natural growth in the forests, and systems of permanent production may be developed, instead of rubber districts producing for only a few years. Commercial interests suffered when the sending of rubber-gatherers into the remote forests became unprofitable, but with regular production of rubber settled populations may be established in many of the rubber districts, and Brazil again may become the principal source of rubber.

OTHER VERNACULAR NAMES

The primitive people who inhabited the forested regions of tropical America lived in small, widely separated groups, each tribe with its own language and with different names for most of the natural products. The rubber of the *Castilla* tree had the name *cauchuc* in the language of the Incas, now called Quichua. The French spelling is *caoutchouc*, and the modern Spanish form is *caucho*, the word that still is used as the name of *Castilla* rubber, not only in Ecuador and Peru, but also in Brazil. *Castilla* as well as *Siphonia* existed in all the rubber areas of the Amazon Valley, and caucho rubber still is exported in commercial quantities, especially where new districts are being opened.

The name *caucho* is not applied in South America to the rubber of the *Siphonia* tree, but a Portuguese name *borracha*, meaning *bottle* in the original sense of a leather wine-skin. Some of the tribes along the Amazon knew how to make bottles and squirt-guns by spreading the latex over an earthen mold, curing the rubber in the smoke of palm-nuts, then crumbling and washing out the earthen material. Some writers have supposed that the *Siphonia* tree was called *syringa* by the Portuguese colonists because syringes as well as bottles were made of the latex, but a simpler explanation may be that the flowers are clustered like lilacs and have the same fragrance. The men who gather the *Siphonia* rubber are called *seringueiros*, while the *caucheros* are those who collect the *Castilla* rubber, a different occupation.

The Aztec name for *Castilla* rubber, *ule* or *hule*, was recorded by a Spanish historian, Sahagun, who arrived in Mexico in 1529, more than two centuries before La Condamine reached South America. In the seventeenth century another Spanish writer, Cobo, recorded the Peruvian name *cauchuc*, and identified it with the *ule* of Mexico,

"which is well known in all the Indies." The leaves, branches, and fruits of the tree are described to an extent that leaves no doubt of it being *Castilla*. Cobo's book, *Historia del Mundo Nuevo*, written in 1653, was published in Seville in 1891. No warrant has been found for a statement in a recent textbook of economic botany that the name *cahuchu* was derived from "primitive Central American Indians." Many other names, as *sheve*, *sabac*, *sabbe*, *zini*, *sini*, and *seru*, are recorded in Lehmann's *Zentral Amerika* as equivalents of *ule* or *caucho* in native languages of Ecuador, Colombia, Panama, Costa Rica, and Nicaragua. The *tunu* or bark-cloth tree of the Mosquito coast is a species of *Castilla*, said to produce only inferior rubber.

Rubber from some of the "West coast" districts still is called *jebe* as a trade name. The word is defined in several Spanish dictionaries as *caucho* or *goma elastica*, indicating that the two words were separately adopted from different native languages of "Peru" in the colonial period. At the beginning of the nineteenth century Humboldt and Bonpland reported the name *caoutchouc* as associated in Colombia with two species of *Ficus*, and with a species of *Lobelia* growing as a tree 20 to 30 feet tall, at altitudes of 6,000 to 9,000 feet, in the mountains around Popayan.

TREATMENT OF HOMONYMS

The name *Siphonia* was substituted for *Hevea* by Lamarck on plate 790 of the *Encyclopédie*, but the illustrations did not appear till 1798. The change was noted in the second volume of the Supplement, published in 1812, but the volume with *Siphonia* in alphabetic sequence was delayed to 1817. The publication of *Siphonia* usually is dated from Schreber's *Genera plantarum*, 1791, where the name is credited to Richard, who probably suggested it to Lamarck. Willdenow, in 1805, seems to have been the first author to publish a species under *Siphonia*, with Richard as the author of the specific name, *Siphonia cahuchu*, and *Hevea guianensis* Aublet as a synonym.

Another generic substitute, *Caoutchoua*, was proposed by Gmelin in the same year with Schrader's publication of *Siphonia*, 1791, and was accompanied by a specific name, *Caoutchoua elastica*. Thus *Caoutchoua* appears as technically established 14 years before *Siphonia* was equipped with a species by Willdenow. Rules of nomenclature, strictly interpreted, would require this name *Caoutchoua* to be used, with the type species as *Caoutchoua guianensis* (Aublet), a new combination.

The underlying objection to *Caoutchoua* being accepted instead of

Siphonia is the same as against *Hevea*—the confusion inherent in the fact that the vernacular name *cauchuc* or *caoutchouc* related originally to the *Castilla* tree and was not properly available as a name for the *Siphonia* tree of the Amazon Valley. Misplacement of vernacular names in scientific terminology obviously is unwarranted, and doubtless will be condemned in codes of nomenclature. If botany stood entirely alone, arbitrary borrowing of vernacular names conceivably might be tolerated, but for botanical terminology to remain permanently at variance with the neighboring sciences, as philology, ethnology, and pharmacology, is scarcely thinkable.

Formerly it was considered that homonyms might be revived where the earlier use of a name had proved invalid. Thus in DeCandolle's *Prodromus* the name *Evea* Aublet was placed as a synonym of *Cephalaeis*, and this may have been supposed to allow the revival of *Hevea*, but later writers have treated *Evea* as a distinct genus. The instability of names resulting from such variations of opinion among taxonomists resulted in the rule against homonyms being revived, after once being discarded. There is nothing to indicate that Mueller took account of the early history of *Hevea* or of the objection to homonyms being restored.

If the names are not words to be spoken, but only graphic symbols to be copied on labels and catalogue cards, the difference of a silent letter may seem sufficient, since it gives a visible difference, if not vocable. The earlier botanists undoubtedly thought of speaking the names, so that homonyms quite definitely included homophones. Thus it is possible to object that the names were not identical, and that substitution of *Siphonia* for *Hevea* was not warranted, but the fact remains that the change actually was made and was generally adopted, and that such rejections of names have been considered as irreversible, under rules of nomenclature. "Once a homonym always a synonym." No object is gained by going back to a doubtful or debatable name, once it has been challenged and discarded as causing confusion. Treating one name as dependent on variable opinion regarding the availability of another name obviously conflicts with the primary need of stability in nomenclature.

MISLEADING NAMES FOR THE SPECIES

The name *brasiliensis*, generally associated with the cultivated rubber tree, was borrowed from a related species, not found in the lower Amazon Valley but on the southern frontier of Venezuela, along the streams that connect the head waters of the Orinoco and the Rio

Negro, a region explored in 1800 by Humboldt and Bonpland. The description of the tree was published by Humboldt, Bonpland, and Kunth under the name *Siphonia brasiliensis* in 1825, in the last volume of the monumental work on the plants of Humboldt's travels in tropical America, *Nova genera et species plantarum* 7:170. Two localities were reported and two native names, *jacio* for the tree and *dapiche* for the white rubber, "*caoutchouc album*," said to adhere to the roots, presumably as exposed on the banks of the rivers. Pittier has *jacia* as a native name in Venezuela, but not *dapiche*.

The name *brasiliensis* seems to have been occasioned by the Humboldt specimen being compared by Kunth with a specimen in the Willdenow herbarium, to which the name *Siphonia brasiliensis* had been attached, but without being published. It is hardly to be maintained that the use of this name by Kunth constituted a publication of the Willdenow species. A name is not authenticated by being mentioned in synonymy or by being printed with a description of a different species. Instead of basing his description on the Willdenow plant, Kunth stated in a footnote that the Willdenow specimen had smaller leaves, paler underneath.

The normal assumption would be that the name belongs to the Humboldt species, the association that is recognized in the *Index Kewensis* and other reference works. Since Brazil at that time was a geographic expression rather than a political entity, the name *brasiliensis* would not have appeared inappropriate for any tree from the vast central forest of South America. The proposal of Baillon in 1858 that the Humboldt tree be assigned a different name, *Siphonia kunthiana*, would avoid for this species the confusion involved in the name *brasiliensis*, but for the cultivated rubber tree the name *brasiliensis* would still be ambiguous, leading back inevitably to the Humboldt rubber tree and to the long confusion of the two species. Lamarck recognized in 1789 that the rubber tree of the lower Amazon was different from Aublet's Guiana species, but the Humboldt tree was accepted by many writers as the source of commercial rubber. Even in Mueller's critical revisions of the group in DeCandolle's *Prodromus*, 1866, and *Flora Brasiliensis*, 1874, the two species were not separated, Baillon's *Siphonia kunthiana* being placed as a synonym of "*Hevea brasiliensis* Muell. Arg." No specimens of the fruits or the seeds were seen by Mueller.

Owing doubtless to the confusion of the two species, no detailed account of the lower Amazon rubber tree was furnished, but in 1874 a description was drawn from specimens grown at Rio Janeiro, which

Mueller did not recognize as the Para rubber tree, and published as a new species under the name *Hevea janeirensis*. This name may be transferred to *Siphonia* as a new combination, *Siphonia janeirensis*, but using this name for the cultivated rubber tree would create more confusion, as if a Florida plant that happened to be grown in Canada were named *canadensis*. The case is parallel to the use of *Asclepias syriaca* as the name of our New England milkweed, and *Simmondsia chinensis* for the jojoba nut of southern California and Arizona, plants not native in Syria or in China or having any relation to those countries except as specimens were wrongly labeled. The use of such names, admittedly erroneous and misleading, marks a phase of professionalism among herbarium workers that doubtless will prove temporary.

For filing pressed specimens in herbaria, one name may serve as well as another, but in field and garden studies these misleading names are a permanent handicap, requiring always to be "corrected" and explained anew to each generation of botanists and plantsmen. If the name *Siphonia janeirensis* were used, all future generations of botanists and writers on rubber would need to be cautioned and checked against the natural assumption of a native rubber tree at Rio Janeiro in southern Brazil, hundreds of miles beyond the natural range of distribution of the species, or of other members of the genus. The name in itself is of little moment, but avoiding confusion is important. In writing *Siphonia ridleyana* we acknowledge our debt to Ridley and also admit the need of more care in naming plants.

A RIVERINE HYBRID

An extreme variability of the cultivated rubber tree may be connected with the biological status of the wild stock in South America. Because of the geographic position of the species in the lower Amazon Valley and the adaptation of the seeds for floating, unusual conditions for hybridization are afforded, not as a rare contingency but as a normal occurrence. Swollen currents from the upper river often reverse the flow of the lower tributaries, so that floating seeds may be stranded far from the main channel. Thus the stock of *Siphonia* over a wide area of the lower valley must have remained continually accessible to crossing with the several up-river species. Hybridizing as a preliminary to selection has been accomplished in nature.

The range of variation in *Siphonia ridleyana* may be found to include all the characters of the other species, when these are definitely known, and with endless abnormalities appearing among the seed-

lings, beyond the range of the parental types, comparable to the extra-parental diversities shown in perjugate hybrids between different species of cotton, as described and illustrated in the Journal of Heredity for February, 1915. The same problem is presented, of finding among the infinite wrack of degenerating forms any lines of descent with desirable characters in stable patterns, "coming true" from seed. High-yielding types are being utilized by budding, but are only a partial solution of the trading problem. Uniform seed-stocks would be much more valuable. Comparing progenies of tree-crops in order to determine uniformity is an experimental undertaking of vast proportions, in which all the rubber-growing countries might well cooperate.

The diversity in the cultivated stock of *Siphonia* is comparable with that of some of our animals and plants that have been domesticated for long periods, as cattle, horses, dogs, wheat, cucurbits, and potatoes. The range of characters in these long-domesticated groups is supposed not to have been derived from a single wild stock but from several related species developed in different regions, but brought together and mongrelized in primitive times. Diversity is found among the members of all the wild species of plants and of animals that are studied carefully, but usually the diversity is less than in the cultivated stock of *Siphonia*. Other species are considered in Ducke's *Revision* to be as variable as "*brasiliensis*," and this would be expected of any stocks similarly exposed to crossing.

The trees are found to differ not only in the stature and growth of the trees, the leaves, floral characters, and seeds, but also in the bark texture and in the latex tubes, which determine the yield of rubber. The surface of the bark may be smooth or finely wrinkled like a beech tree, or rough and rimose like an elm or an oak, while the texture may be uniform, soft and cheesy, or brittle and gritty with stone-cells. Records show some trees yielding scarcely any rubber, and others only small amounts, with a few far above the general average, so that 75 per cent of the rubber is produced by 15 to 25 per cent of the trees. Budding from high-yielding trees raises the average, although yields vary as before, on account of diversity of the stocks.

To exhibit the diversity of leaf-forms many illustrations would be required. A single example is given in Fig. 1, showing in natural size two slender leaves from an abnormal plant, compared with a normal leaf. The closer and more numerous primary veins of the abnormal pinnae should be noted, as well as the narrow outlines and crenate margins. Many variations have still narrower pinnae, and the margins notched to the midrib, while others have curved or twisted pinnae,



Fig. 1.—*Siphonia ridleyana*, a normal leaf overlain by two abnormal leaves. Natural size.

or funnel-shaped "ascidia." The series of foliar aberrations is comparable to that of the familiar "crotons" or codiaeums, which also belong to the spurge family.

Pinnae of normal form are only two or three times as long as wide, while some of the abnormal pinnae are 10 times as long as wide, or even 20 times as long. Most of the extreme mutants are outgrown by the normal plants and smothered in the seedbeds, or not transplanted from the nurseries, but a mature narrow-leaved tree, with flowers and fruit, was found in Haiti. The pinnae were slender and tapering, similar to those of the photograph, though not elongate. Some abnormal plants have the stalks of the pinnae longer than usual, or the stalks may be very short and grown together, so that the pinnae do not separate. Leaves with supernumerary pinnae, 4, 5, or 6, are found on trees otherwise normal.

Heavier texture of the foliage may be a factor of resistance to the South American leaf disease, and earlier attainment of the adult foliage is a character to be regarded in selection. Plantations of *Siphonia* are difficult to establish in Brazil and other American countries infested with the leaf disease because many young trees are defoliated and killed. The juvenile stage is specialized, the branches suppressed and the foliage more delicate, adapted to shade conditions in the undergrowth of the forest, as explained in Science.³

SIPHONIA ADAPTED TO SMALL FARMING

The system of large plantations operated by contract labor, as practiced in the oriental countries, may not be feasible in tropical America, but other modes of production may be developed that do not require large undertakings. The momentum of a vast industry makes it difficult to think of planting trees in hundreds instead of thousands. In reality the *Siphonia* tree, under the Ridley method of tapping, is as well suited to small independent producers as to large estates, thus avoiding the "overhead" expenses that often absorb more than half the outlay in opening plantations. All the tropical American countries are users of rubber, and all may become regular producers. First efforts in new districts may fail because the seeds are short-lived and the seedlings rather delicate, but once the trees are established they are likely to become a permanent resource. Where beginnings are assisted and seeds or budded stocks are available, the trees can be grown among other crops with little labor or expense, merely replac-

³ Science 71: 386-387. 1930.

ing some of the nonproductive trees that often serve in tropical gardens or orchards for shade or wind protection.

Castilla often has been used as a shade tree, but a regular yield of rubber is not obtainable. Because the *Castilla* latex flows freely at the first tapping, there is much more danger of the rubber being stolen and the trees killed or permanently injured by marauders. More labor is required to harvest the rubber of *Siphonia*, but production is regular. Even a hundred *Siphonia* trees, the planting quota of a single acre, may engage the interest of self-supporting families in all the countries where the tropical tree-crops are grown, notably coffee and cacao, where avocados, papayas, guavas, or citrus fruits are grown, as in southern Florida. The rubber trees would be tapped every second or third day, requiring an hour of labor and affording a return of a dollar or more from each hundred trees. The work is light and clean and is done in the cool of the morning.

Experiments in southern Florida, near Coconut Grove, indicate that *Siphonia* and other tropical rubber trees, as *Castilla*, *Funtumia*, and *Manihot*, are adapted to the local conditions, flowering and seeding abundantly. Rubber produced by *Siphonia* trees in Florida has been tested by the National Bureau of Standards, and excellent quality found. Popular interest may lead to general planting of *Siphonia* and the other rubber-bearing types in southern Florida, at least as garden trees, and with fresh latex at hand new uses of rubber or improved manufacturing processes may be worked out. The stocks may be improved by selective breeding and through survival of the hardier trees in periods of unusual cold. Hardier strains developed in Florida might be of use in Mexico and in many other countries. The extent of tolerance of low temperatures or other unfavorable conditions is still to be determined. Apart from any question of producing commercial quantities of rubber in Florida, the information and experience that would be gained by planting rubber trees in different localities in Florida might be of great value in extending the range of rubber planting among resident populations in tropical America.

The limitation of the genus *Siphonia* to the Amazon Valley and the eastern slopes of the Andes carries no implication that planted trees will not thrive in the Pacific belt of Ecuador and Colombia and in other parts of tropical America, as they have in Asia and Africa. The natural distribution of the South American leaf disease is still unknown. It has not been found in Haiti or in Florida, and it may be absent from other islands or parts of the mainland, although it has appeared in Dutch Guiana, Trinidad, and Costa Rica.